From mura@rcnp.osaka-u.ac.jp Sun Jul 25 10:55:10 2004
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Cc: mura@rcnp.osaka-u.ac.jp
Subject: Re: Pentaquarks in E949?

Hi,

I did a toy Monte Carlo simulation to produce $K^+ + n \rightarrow \Theta^+ \rightarrow K^0 p \rightarrow \pi^+\pi^- p$ events. This study is very initial one and I really appreciate your comments, corrections and discussions. All the figures which appear below are attached to this e-mail as theta_e949.pdf.

First I assumed K^+ momentum equals to 440 MeV/c (with zero resolution) so that CMS energy calculated with a rest neutron should be consistent with Θ^+ mass (1540 MeV/c^2). Fermi motion of neutrons were included in the simulation by using harmonic oscillator model inside a carbon, which reproduces (e,e'p) experimental data. (See Fig.1) I applied a filter with the Breit-Wigner shape (10 MeV width was assumed) to CMS energies of the generated events so that Theta+ resonance can be obtained. (Fig.2) Then I generated Θ^+, K^0 and proton tracks flatly in both azimuthal and polar angles at CMS. Pairs of π^+ and π^- were also flatly generated at K^0 rest frame. Finally I transformed all the generated 4-momenta to the Lab frame by Lorentz transformation. I confirmed 4-momentum conservation and flatness of generated tracks in the toy MC simulation. Momentum distributions, polar angle distributions and scatter plots of polar angle vs momentum for π^+, π^-, K^0 and proton tracks viewed at the Lab frame were shown in Fig.3, 4 and 5, respectively.

Geometrical acceptance of E949 detector was estimated by requiring the tracks pass through -25 cm < z < 25 cm at the outer radius of UTC (r=43.1 cm). Both the case where two pions are detected and the case where all of pions and proton are detected were examined. Event generations were performed at z=0 cm, -10 cm and -20 cm. Here is the table of the acceptance study:

	two pions (K^0)	two pions + proton
z= 0cm	2543/20589 = 0.1235	12/20589 = 0.0006
z=-10cm	2566/20655 = 0.1242	376/20655 = 0.0182
z=-20cm	2181/20655 = 0.1056	1243/20655 = 0.0602

Of course the detections of all the tracks is better for the purpose of reconstruction because invariant masses will not be affected by Fermi motion. But we can enhance the statistics by detecting only K_S and by correcting Fermi motion with $\pi^+\pi^-$ missing mass ($MM(K^+,\pi^+\pi^-)$). This is shown in Fig.6, which plots true CMS energy vs $MM(K^+,\pi^+\pi^-)$. (I omitted Θ^+ resonance filter for this plot. Also note that the slope looks different for different K^0 polar angles.) Correspondences of Fig.3-5 after requiring to detect two pions from z=0 cm are shown in Fig.7-9.

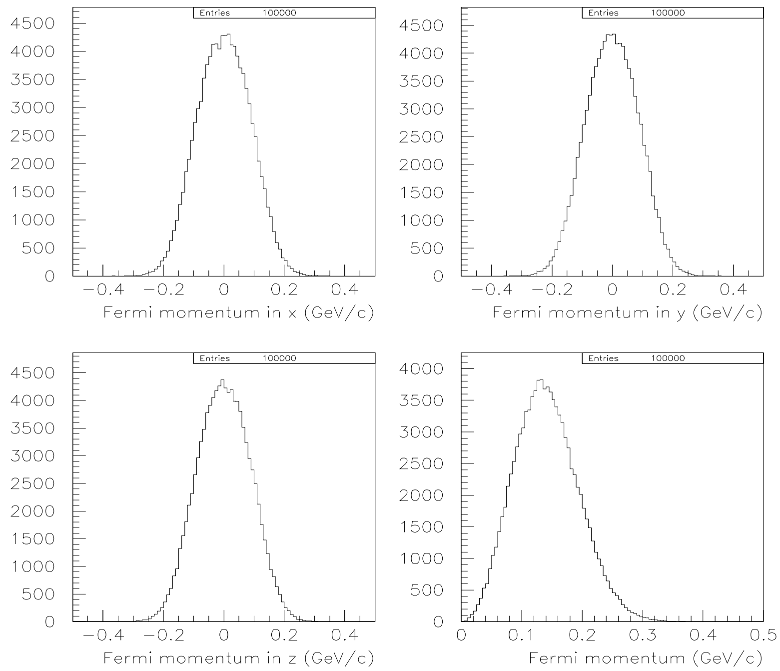
If it is required that all tracks from z=-20 cm are detected, momenta and polar angles are distributed as shown in Fig.10-12. Correlations of polar angles between K^0 and proton are shown in the top-left panel of Fig.13 (two pions required) and Fig.14 (all tracks required), and a detectable region is shifted by changing the generation point from z=0 cm to z=-20 cm.

Main background should be charge exchange events. We can refer to PRD**15** (1977), 1846-1850. Differential cross sections suggest more K^0 production at forward angles at CMS. Total cross section was measured to be ~7mb. Fig.15 (two pions required) and Fig.16 (all tracks required) show cosines of K^0 polar angles at z=0 cm, -10 cm and -20 cm. They can be compared with Fig.4 of the above reference. The two pion requirement at z=0 cm seems to be most separated from the BG. Since the DIANA collaboration at ITEP has reported a 4.4σ enhancement of Θ^+ (# of signal is ~20 events, though. See hep-ex/0304040.) in the reaction of K^+Xe-> K^0pXe', we have a chance to observe Θ^+ resonance above the charge exchange background. If I assume ~1 mb of Θ^+ cross section, ~30 events per 1 M K^+ beam and 1 cm-thickness of the target (I assumed CH) seems to be expected by 1 mb (cross section) x 1 cm (target thickness) x 6.022x10^{23} (Avo. #) x 1.032 g/cm^3 (target density) / 13 (A of CH) x 6 (neutrons in C) x 10^6 (K^+ flux) x 0.1 (geometrical acceptance). So high statistics experiment seems to be possible.

Here I list a few questions to consider about the experimental possibilities.

(1) What will be a typical momentum resolution of the K^+ beam at ~440 MeV/c?
(2) Is there a space to put TOF counters to measure the K^+ momentum event by event?
(3) Is it possible to vary the K^+ beam momentum, for example, at ~20 settings in each 10-20 MeV/c?

Regards,
Norihito Muramatsu



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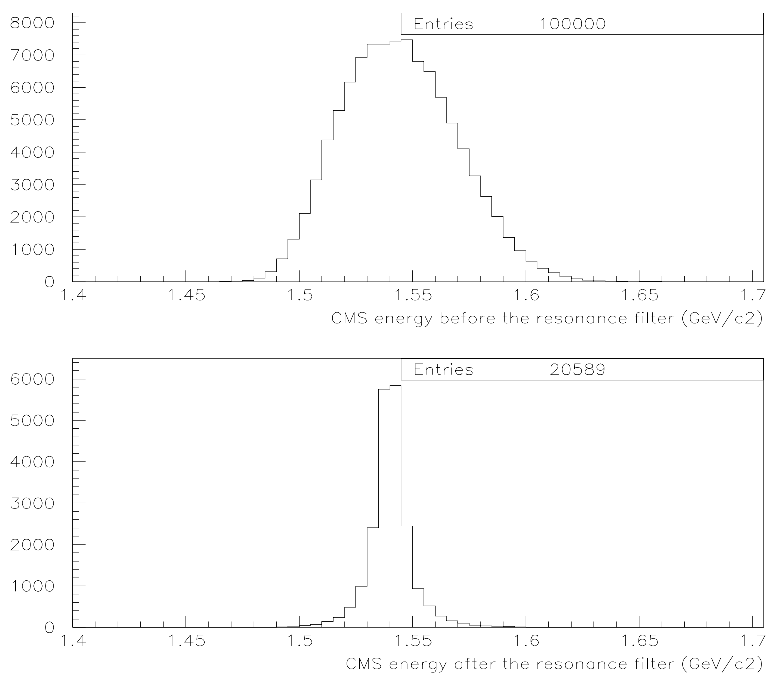

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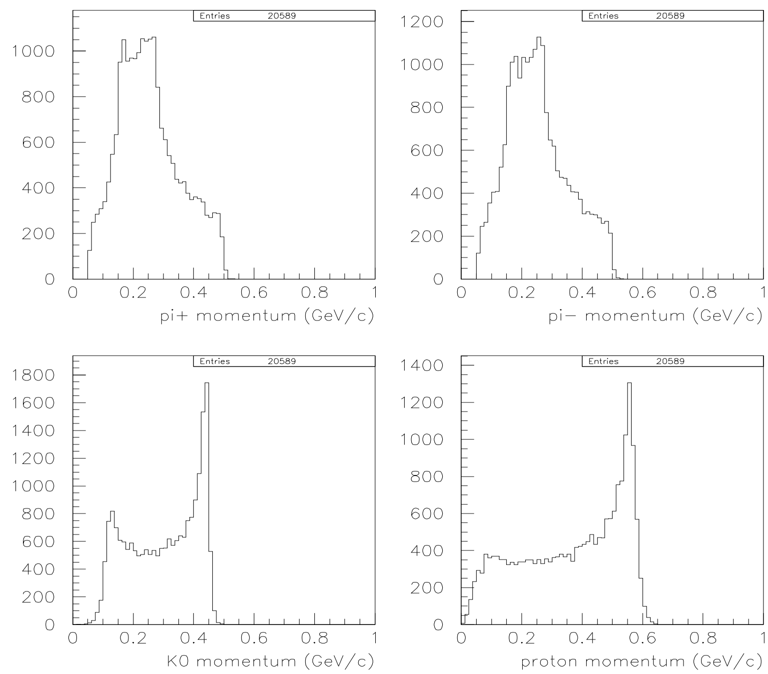

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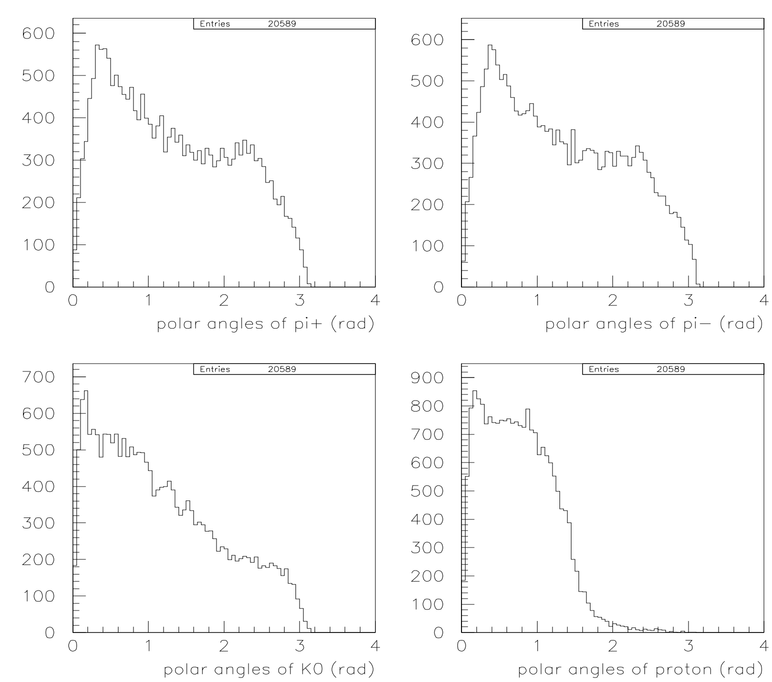

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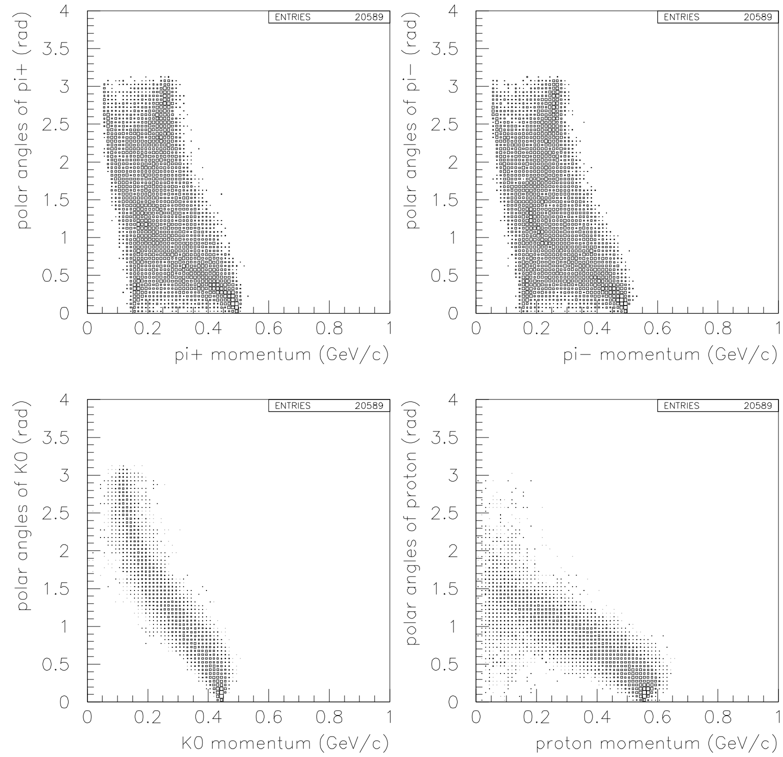

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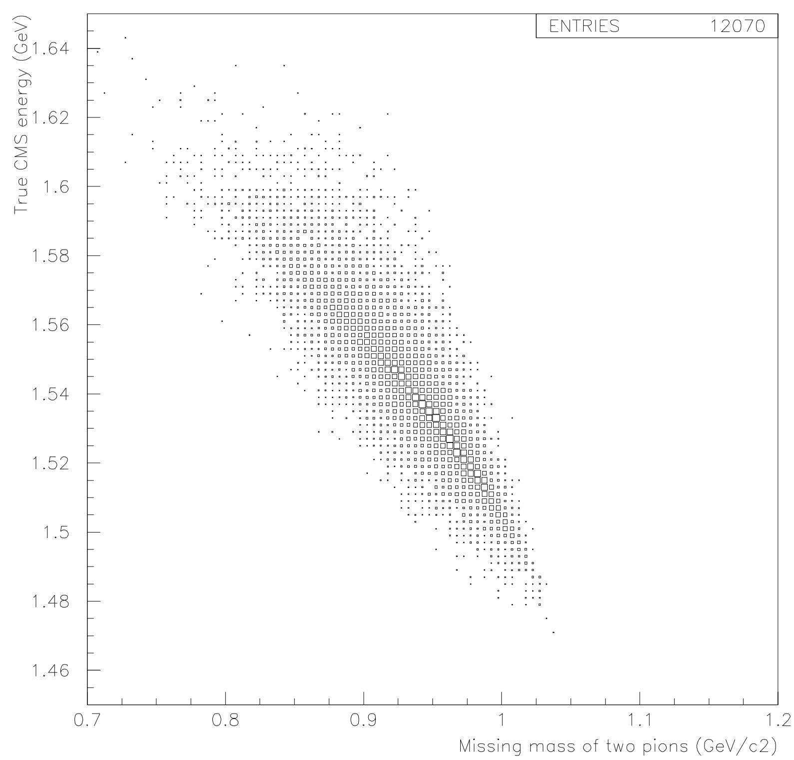

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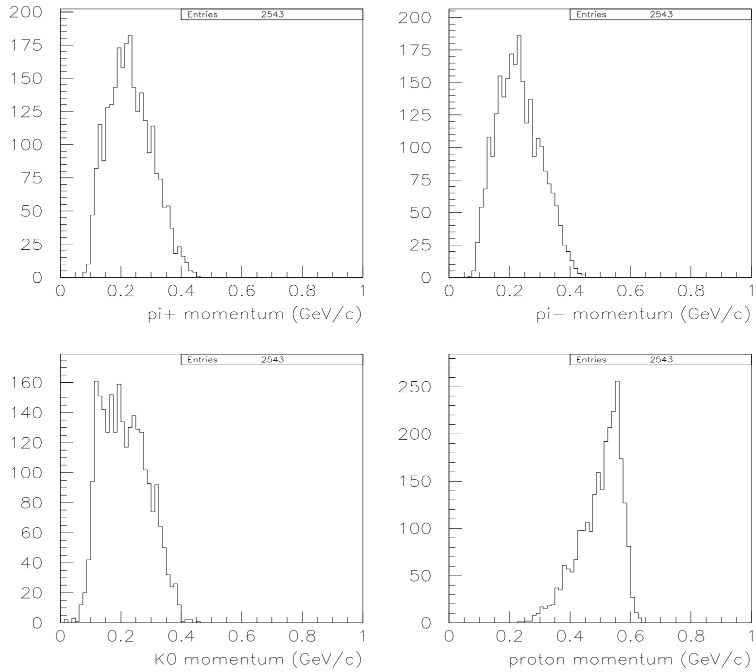

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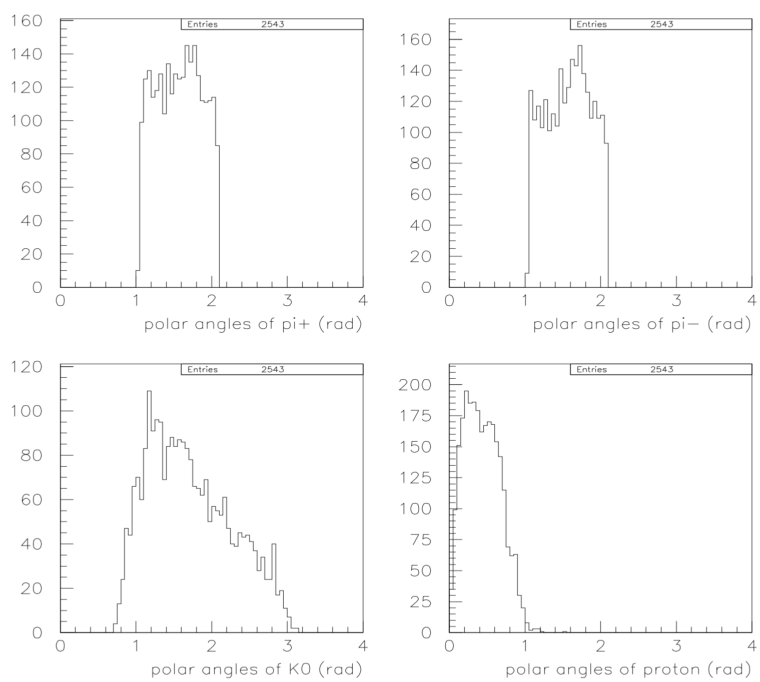

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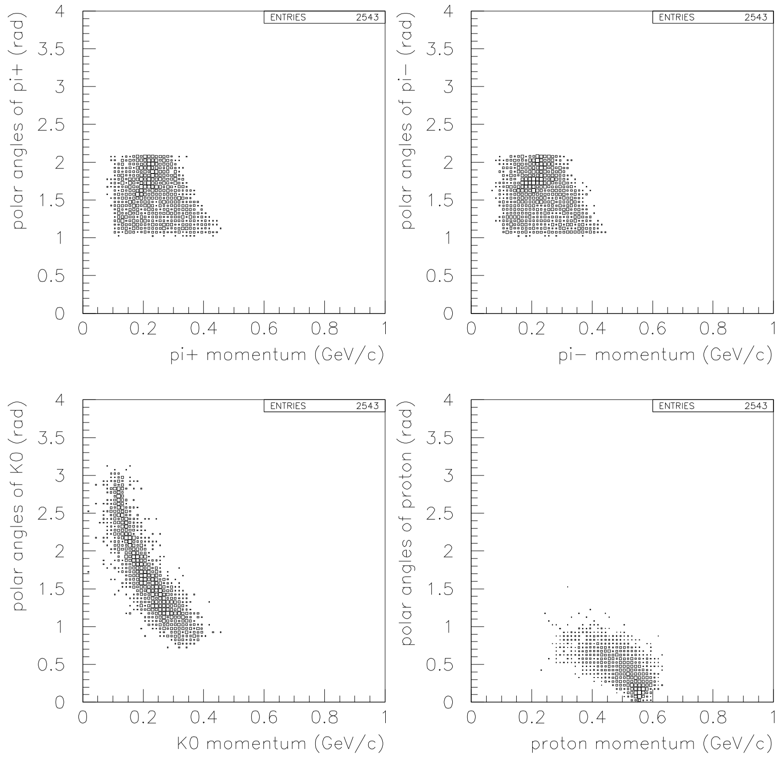

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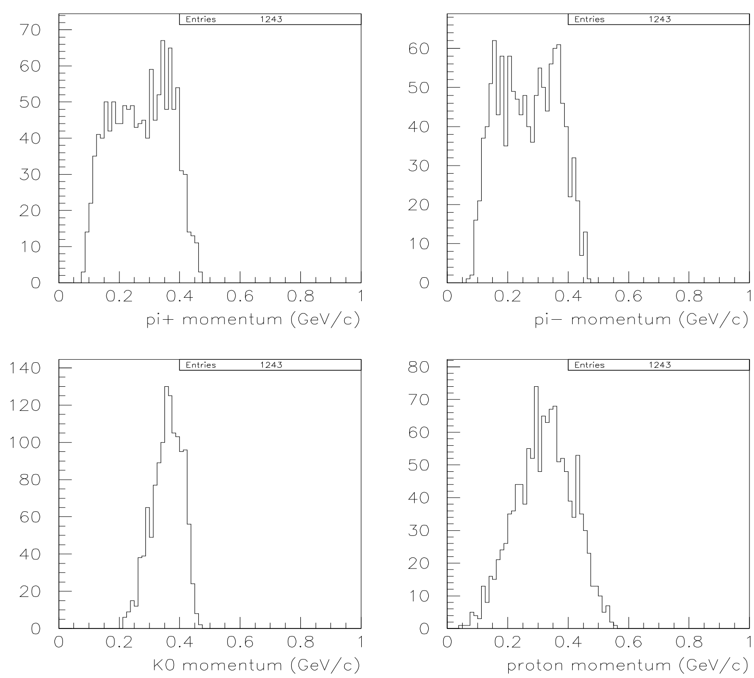

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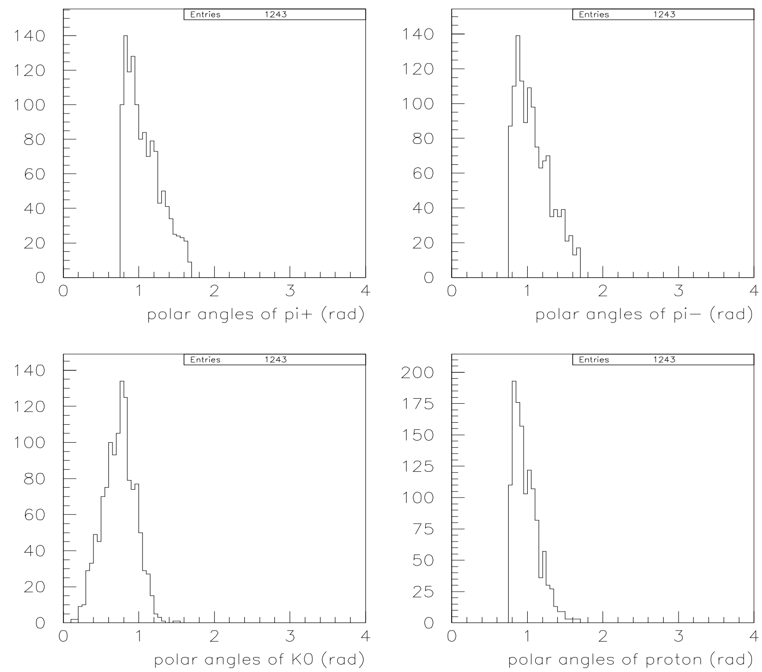

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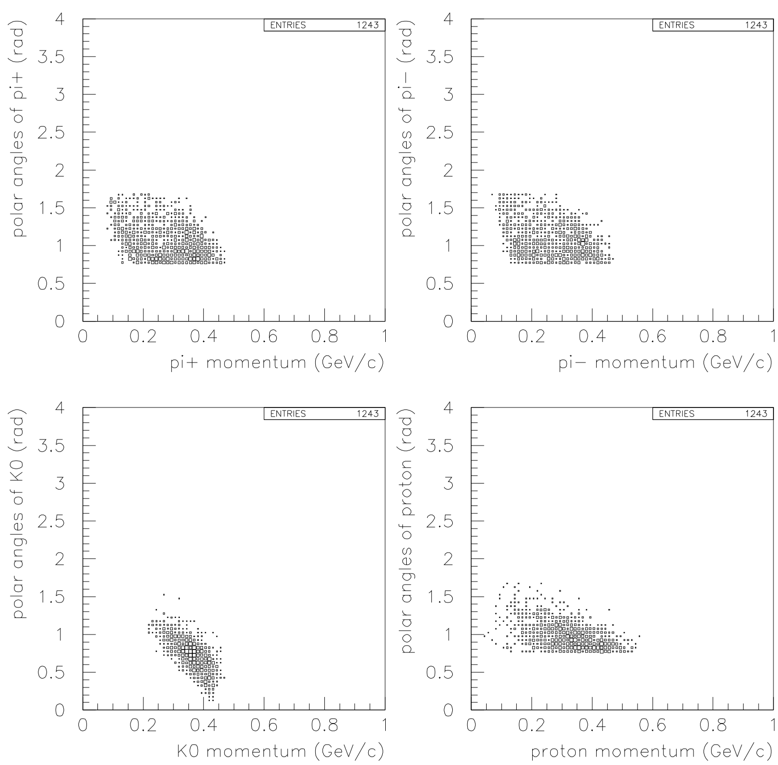

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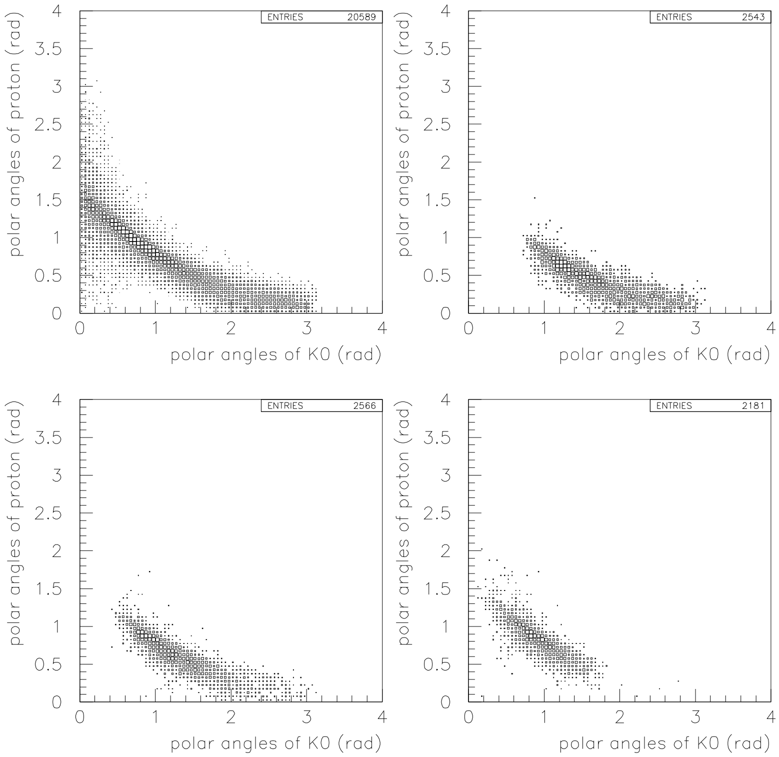

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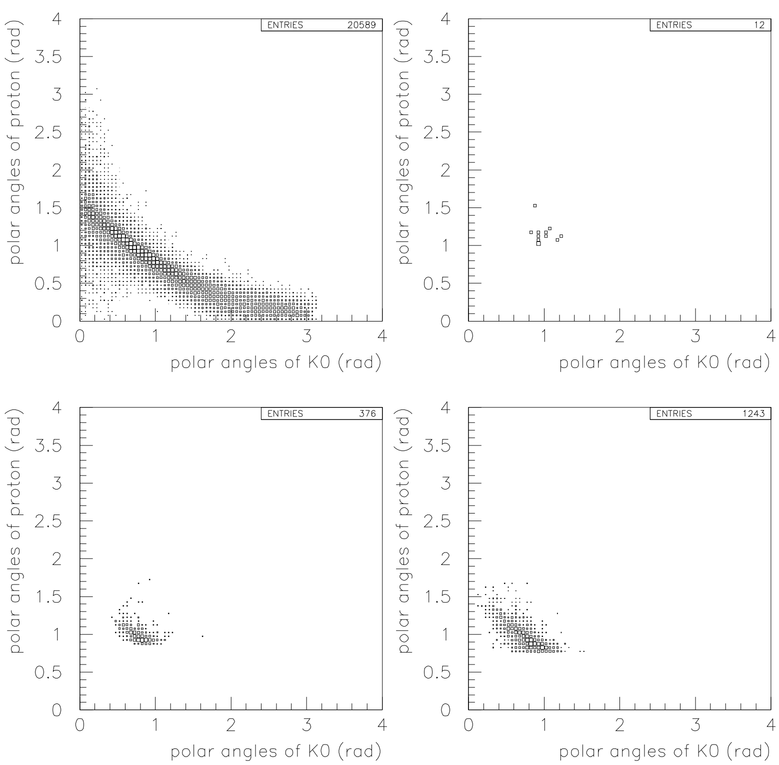

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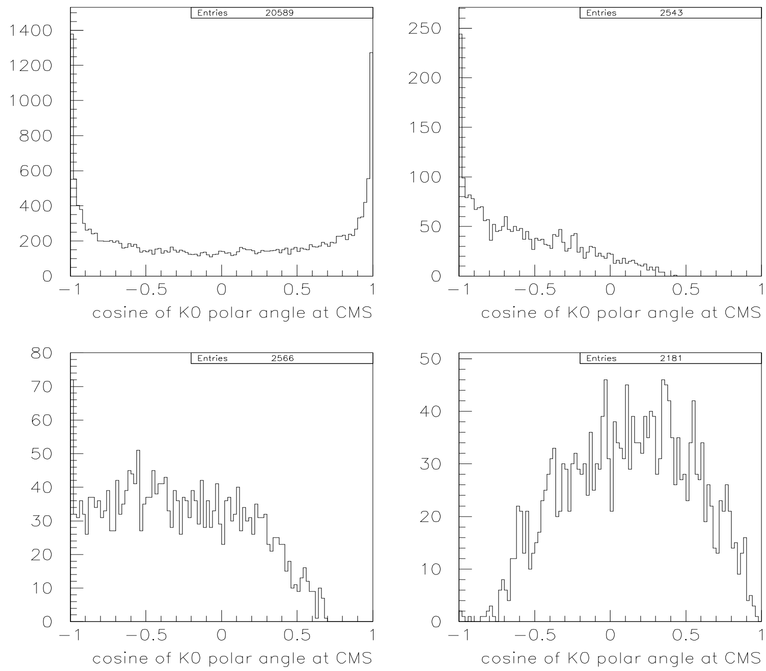

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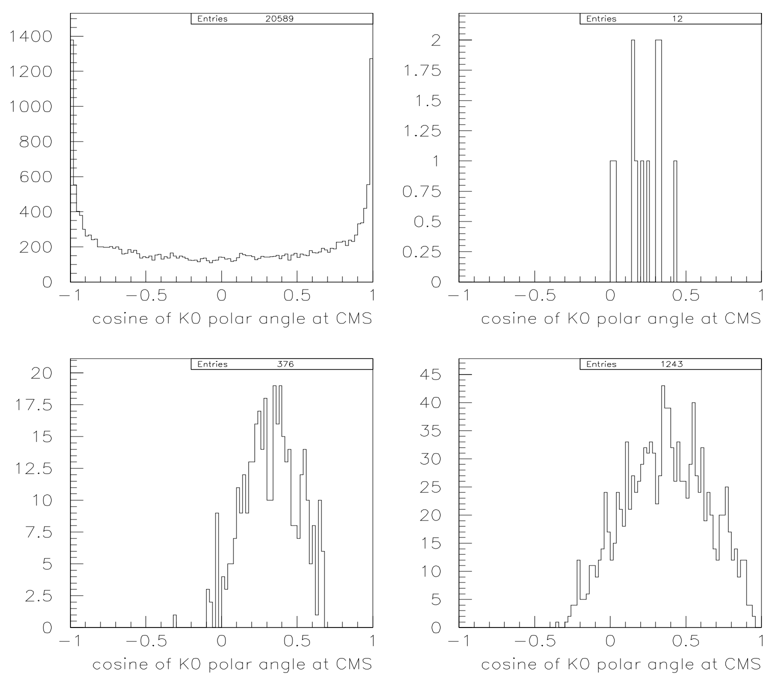

Figure 16: